

Impulse Noise and Neurosensory Hearing Loss

Relationship to Small Arms Fire

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● *The problems of noise are not limited to the simple annoyance of an individual. Noise can produce a permanent hearing handicap. Many everyday activities and hobbies are associated with hazardous exposure to noise. The hunter and the sport shooter are potential subjects of severe and unresolvable hearing loss.*

Noise-induced hearing loss develops insidiously. The means of prevention are far more simple than is correction of the loss. Wearing ear protectors, plugs or earmuffs, is advisable during exposure to hazardous noise.

THE DANGER OF standing in front of a firearm is well known. But not many people are aware that being close beside or behind a gun when it is discharged may cause permanent loss of hearing. Since the hearing loss associated with such exposure is of a "nerve" type, none of the dramatic restorative operations used on conductive hearing problems can be applied in these cases. If in time this hearing loss is not restored by the recuperative powers of the individual, the impairment remains all his life and he is handicapped to the extent of his need for hearing acuity. The resulting problems in communication may even endanger his job, home and social security.

The purpose of this paper is primarily to point out the hazards of being exposed to noise sources which are an intrinsic part of our everyday life.

While there has been increasing emphasis on

the problem of air and water pollution, comparatively little concern has been directed toward noise pollution. Environmental noise is for the most part directly related to the technological advancements of society.

It has been estimated that the average noise level of the average city has increased by about one decibel per year for the past 30 years. It should be remembered that the decibel represents a logarithmic increase in the sound level and not an arithmetic increase, so that in this 30 years' time the sound pressure has increased a thousandfold. The advantages offered by technological advancement are noteworthy. However, noise and its complications have introduced a number of problems, not only for otologists but for society in general.

There are two types of noise. The first is the one that is most generally considered when people talk about noise—that is, steady-state noise. Noise of this type is defined as a periodic or random variation in the atmospheric pressure at audible frequencies which has a positive pressure envelope duration in excess of one second.

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TABLE 1.—Intensity in Decibels of Various Familiar Noise Sources.

| | |
|----------------------------------|-------------------------------------|
| Breathing—10 db | Jack-hammer—94 db |
| Whisper—20 db | A power mower—107 db |
| Low street noise— 40 to 50 db | Motorcycle—110 db |
| Conversation—60 to 70 db | Discotheque 110 to 120 db |
| Food blender—88 db | Jet airplane at take-off— 150 db |

The other kind of noise, which is called impulse noise, has characteristics which are quite different from steady-state noise and involves physiologic responses which differ significantly from those found in steady-state noise exposure. Noise of this type is defined as a non-periodic variation in atmospheric pressure which may completely be described by its pressure in relation to its duration. It has a positive pressure envelope duration of less than a thousand milliseconds and a peak-to-root mean square value greater than 10 decibels. As can be seen, the difference in duration is the key distinction between the two types.

Most of our hearing conservation criteria have been established on the basis of studies done on steady-state noise. According to these standards, if a person is exposed to such noise at levels of 85 decibels or more during an eight-hour work period, this would constitute hazardous noise exposure. Levels of 95 decibels or more require even closer attention, and criteria require that the person use a device such as ear plugs or earmuffs for protection of his hearing. For most persons these figures have relatively little meaning until we see these intensities compared with noise sources familiar to us. Table 1 lists a number of examples and gives the approximate intensity of sound produced.

Most of these examples are steady-state noise. In these circumstances the key factor to be considered is the relatively gradual exposure of the ear to the noise. In the case of a discharging firearm, however, there is swift and acute exposure. In this case the noise reaches a peak intensity within a period of 200 microseconds to 2 milliseconds (depending on the method of measurement). Protection against such noise exposure by the contraction of the middle ear muscles is completely out of the question, since the time required for these muscles to contract and dampen the mobility of the tympanic membrane and the attached ossicles is 100 to 150 milliseconds.

Once contraction of the middle ear muscles has taken place, the ear is offered some degree of protection against further noise exposure for the next one or two seconds. If no further noise stimuli are produced, the aural reflex relaxes. This reflex is of critical importance to persons using firearms—hunters, law enforcement officers, competition shooters and soldiers.

The intensity of noise produced by firearms has been actively investigated, especially by military organizations. Because of the short duration of such noise, studies of the intensity and frequency spectrum have been technically difficult. Present determinations indicate that small firearms (any weapon below .60 caliber) generate from 140 to 160 decibels of sound. The present methods of frequency analysis indicate that the frequencies involved are mainly at 2000 cycles per second and above. In a recent study,¹ a number of observations were made. A group of¹⁴ healthy male patients with previously normal audiograms were found to have significant hearing losses following a short period of exposure to the noise made by firing a small firearm. Thirteen of the 14 persons had qualified with the now well-known M16 rifle (a high-powered 22-caliber rifle). The other qualified with only a 38-caliber revolver similar to those carried by most law enforcement officers.

Immediately following this course of firearms qualification, the patients noted the presence of tinnitus, aural fullness, and subjective hearing loss. It was because of these symptoms that the patients became concerned about their ears and sought medical help. When pure-tone audiometry was done, a sensorineural hearing loss was seen in all cases. This impairment was most pronounced in the left ear in all but one, the person who fired the revolver. When comparing the audiograms with those done on these men either at the time of their induction or as a part of their routine follow-up physical examination, a pronounced change in hearing acuity was evident. Table 2 compares the pre- and post-exposure thresholds and demonstrates the definite drop in threshold responses found in both ears. As can be seen, the left ear suffered a much greater loss in hearing acuity than the right. This disparity in loss can be better understood by referring to Figure 1, which illustrates the usual posture involved in firing a shoulder-held weapon such as the M16: The head is slightly turned so

TABLE 2.—Comparison of Average Thresholds Preexposure and Postexposure for 14 Patients Who Participated in a Firearms Qualification Course. (ASA 1954 Reference Threshold)

| Frequencies | Right Ear | | | | | | Left Ear | | | | | |
|--------------|-----------|------|------|------|------|------|----------|------|------|------|------|------|
| | 500 | 1000 | 2000 | 3000 | 4000 | 6000 | 500 | 1000 | 2000 | 3000 | 4000 | 6000 |
| Preexposure | -0 | -5 | 0 | -5 | 5 | 0 | 0 | 5 | 0 | 0 | 5 | 5 |
| Postexposure | 5 | 10 | 10 | 15 | 10 | 20 | 15 | 15 | 25 | 35 | 35 | 60 |

TABLE 3.—Comparison of Thresholds Preexposure and Postexposure for Pistol Shooter. (ASA 1954 Reference Threshold)

| Frequencies | Right Ear | | | | | | Left Ear | | | | | |
|--------------|-----------|------|------|------|------|------|----------|------|------|------|------|------|
| | 500 | 1000 | 2000 | 3000 | 4000 | 6000 | 500 | 1000 | 2000 | 3000 | 4000 | 6000 |
| Preexposure | 0 | -5 | -5 | 5 | 5 | 0 | 5 | -5 | -5 | 10 | -5 | -5 |
| Postexposure | 10 | 15 | 15 | 55 | 50 | 65 | 10 | 10 | 15 | 40 | 40 | 50 |

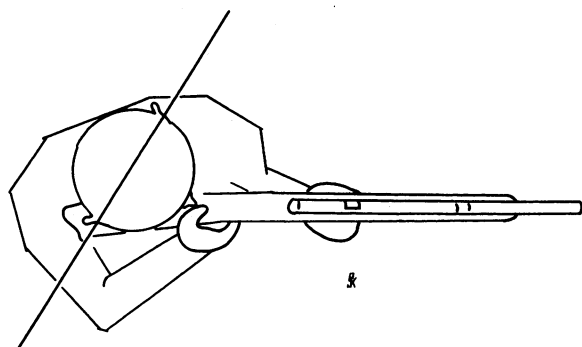


Figure 1.—Relationship of Ears to Shoulder Weapon, as Viewed from Above.

that in the case of a right-handed shooter, the left ear is more directly in line with the noise source. A person shooting with a pistol, although he may turn his body, keeps his head squarely facing the target, thus placing both ears in the same aspect in relationship to the noise source. Turning the head as one does when firing a shoulder-held weapon provides what can be called a "head shadow" for the averted ear.^{2,3} The shadow is considered negligible for frequencies below 1000 cycles per second, but may produce attenuation of as much as 25 to 30 decibels in the higher frequencies. As mentioned before, frequency analysis of firearms noise indicates that the frequencies produced are above 2000 cycles per second. Thus, it is expected that the head would provide some degree of protection for the averted ear in rifle shooting. The audiometric results presented in Table 3 show

the difference in sound effect between rifle firing and the firing of a pistol, in which both ears are equally exposed.

While the "head shadow" produced by the rifleman does result in attenuation of noise, as can be seen in these cases, it did not afford sufficient protection to totally avoid hearing loss in the right or averted ear.

After examining this data, a sportsman may well be justified in asking, "so what?" He may even say, "Sure, every time I go shooting I have a little ringing in my ears, and I can't hear very well for a while but it always goes away." In fact, in most patients these symptoms and the change in hearing acuity may truly be nothing more than transient or what is called a temporary threshold shift. In the case of the 14 patients mentioned earlier, however, this threshold shift was not temporary. Even though in most persons the ears may be capable of repairing this damage to the point that our present methods of audiometry indicate a return to "normal function," permanent stigmata of this exposure may always be present. Further exposure then may add to whatever damage has been done.

One hears often of persons who claim to have been exposed to high noise levels for a great number of years without lessened acuity of hearing, but it must be borne in mind that there is great variation among persons as to sensitivity of hearing mechanism.

Another factor which often is not taken into account is that the type of hearing loss produced by noise exposure of any kind involves deterioration of the higher frequencies first. Since normal communication involves frequencies between 500 and 2000 cycles per second, a long time may elapse before deterioration of hearing progresses to the point that it involves these frequencies. It is of interest that during the period in which the cases previously mentioned were discovered, a great number of patients were evaluated as part of a hearing conservation program, and no

one who wore protectors such as earmuffs while exposed to hazardous noise had hearing loss or aural symptoms. Because we are unable to detect which persons have "tough" and which have "tender" ears, we advocate the general use of protectors by anyone exposed to hazardous noise.

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CONTACT LENS TECHNIQUES FOR THE ELDERLY

"Some elderly patients have a lot of trouble with insertion of contact lenses. If they're bilaterally aphakic, they can't see the lenses. One way we've gotten around that is to give them a little pea-shell frame with a temporary lens in one eye. The other eye has a blank frame. The patient fits the temporary lens first then takes the glasses off and fits the other one. For many patients, this has worked out well. . . . If they still have difficulty, one thing that you can do is to have them pull the lower lid down and just put the lens right on that shelf, release it, and the lens will pop right up into place. That's perhaps one of the easiest ways if they're having trouble with direct insertion. Finally you may have to rely on the spouse, and if the spouse has as much tremor as the patient you may not have gained a thing. . . . Sometimes you just have to work and work with these patients to get them to learn how to put these lenses in correctly.

"As to removal, elderly patients have pretty loose, atonic eyelids, and they have difficulty getting the proper tension on the lid to blink the lens out. When you try to teach them the scissors removal technique, they just can't quite master that. One thing that you can have them do is put a jar of honey in the refrigerator and keep it there. When it gets nice and hard, have the patient dip his little finger into it, get about a 1.5 mm glob of honey, stick it on the lens, and it'll come right out. . . . Another thing you can have them do is get one of the old-fashioned eye cups formerly used in irrigating conjunctivitis. . . . If you have the patient fill this with tap water, pull his lower lid down so that the cup goes into the conjunctival sac inferiorly, and wiggle his eye a little bit, the lens will generally float out. As a last resort, you can provide patients with a suction cup. . . . But I think this is to be used only in an extreme emergency."

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